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Ryzhkov (1947) differentiates between two classes of viruses: virus nucleoproteids and virus liponucleoproteids. He includes in the first class plant viruses and also the causative factors of polyhedral diseases of insects as well as bacteriophage, and in the second class animal viruses. While families have been differentiated within the classes, there is no further subdivision into genera and species. Regarding it as possible to apply to viruses the concept of species, Ryzhkov cannot get away from the treatment of viruses as special substances. This dualism is reflected in his subdivision of viruses into classes. Although the necessity of using the phylogenetic approach to the systematics of viruses has been expressed by Ryzhkov, he has not actually applied this principle.

Holmes (1948) in the 6th edition of the Manual for the Determination of Microorganisms by G. O. Berge proposed a systematization of viruses which embraces the majority of the species known at present. This systematization has serious shortcomings, however, which make it completely unsatisfactory. The author disregards the modifiability of viruses and differentiates between a huge number of species of bacteriophages and plant viruses, many of which are merely varieties of the same species. The subdivision of animal viruses into groups has been carried out in an unsatisfactory manner by Holmes. As a result, such diverse viruses as the causative factor of the foot and-mouth disease (a virus of small dimensions) and that of vesicular stomatitis (a gigantic virus) are relegated to the same genus. The nomenclature of viruses proposed by Holmes arouses indignation. This nomenclature has been drawn from criminological practice: for instance the group of herpes has been named Scelus (criminal). The group of encephalitides has been named Erro (tramp), and the group of infectious anemias Trifur (a declared thief). This gangster nomenclature testifies to the thoroughgoing deterioration of bourgeois science.

For the reasons stated, it seems to us timely to discuss the problem of the systematics and nomenclature of viruses. The systematization that is being proposed was reported on 11 October 1949 to the scientific conference of the Ukrainian Institute imeni Mechnikov at Khar'kov. The original version of the scheme of systematization was somewhat changed in accordance with the comments that were made during the discussion at the conference.

We must first of all decide which microorganisms should be regarded as viruses.

The following properties of viruses are basic and distinguish viruses from all other microorganisms:

1. the small dimensions of the viruses, by reason of which most of the viruses are invisible under the microscope and can be filtered through bacterial filters;
2. the inability of viruses to grow on nutrient media, so that they must be grown on living tissues;
3. the absence of an independent metabolism.

The lack of a self-sufficient and independent metabolism is due to the weak development of the enzymatic systems in viruses, as a result of which they must propagate intracellularly and often show a rigid specificity with regard to the tissue on which they propagate dermatropic, neurotropic, pneumotropic, and other viruses.

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On the basis of the last definition, one must include into the group of viruses not only animal viruses and plant viruses, but also bacteriophages. Rickettsiae are closely related to viruses. Although the majority of them do not pass through bacterial filters, they approach large viruses in size (this applies to the causative factors of psittacosis and of venereal lymphogranuloma). As far as their remaining properties are concerned rickettsiae come under the definition of viruses.

The principal problem of virus systematization is the determination of the place which they occupy among living organisms, their relegation to one of the major systematic groupings (i.e., to a type, class, and order) and furthermore their subdivision into smaller groups, namely families, genera, and species. But first of all, it is necessary to discuss the problem pertaining to the principles of the classification and nomenclature of viruses.

All existing classifications are based on some single characteristic: parasitism in the body of definite hosts, according to Auduroi, Levaditi, and Lepine; adaptation to specific tissues, according to Van Roijen and Rhodes; the clinical syndrome of the diseases which are induced, according to Holmes; or adaptation to specific tissues under consideration of the pathogenesis of the infection, according to Moshkovskiy. Critical analysis of these classifications indicates that none of them can be regarded as satisfactory. Apparently, one cannot use a single criterion or a few criteria for the systematization of viruses, but must take account of the sum total of basic characteristics which are typical for every virus or group of similar viruses, namely the dimensions and morphology, the antigenic structure and immunobiological properties, the enzymatic activity, the biological and metabolic properties, the sensitivity or resistance to definite antibiotics, adaptation to a parasitic life in the organism of specific hosts, the pathogenesis and the clinical aspects of the diseases produced, tissue tropism, and finally the ecological characteristics.

However, even these properties may prove insufficient for the formulation of a biological systematization if an additional factor is not considered, namely, the circumstances that the biological systematics must reflect the evolution of the group which is systematized. The necessity of taking into consideration the evolution which has been undergone arises first of all in connection with the solution of the problem as to whether we are dealing with an animal or a plant virus, and of the question under which systematic subdivision viruses as a whole must be classified, i.e., whether they should be regarded as an order, class or type.

Among possible assumptions in regard to the genesis of viruses, two hypotheses deserve attention. According to one or them, viruses are the degenerated descendants of larger pathogenic microorganisms, i.e., bacteria, fungi, or protozoa.

However, this hypothesis is refuted by a number of facts.

According to the second hypothesis, viruses are degenerated descendants of primary forms of life which existed prior to the appearance of cellular forms and then differentiated into two classes, i.e., animals and plants.

The genetic unity of viruses at the same time does not conflict with the presence among them of such diverse groups as bacteriophages, plant viruses, and animal viruses.

Acceptance of the second hypothesis makes it possible to attempt a systematization of viruses. Viruses must be recognized as a separate type which occupies an intermediate position between animals and plants. There are no substantial grounds to differentiate within these types between large systematic groups and designate them as classes. For that reason it is expedient to regard viruses as belonging to a single class.

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The further breakdown according to orders can be carried out on the following basis. Among the many viruses which are known at the present time, there are three distinct natural groups: viruses which affect lower plants (bacteriophages and agents which have a lytic effect on actinomycetes), viruses which affect higher plants, and viruses which affect animals. It is proposed that these groups be differentiated as separate orders. The following nomenclature of the major systematic groups is proposed:

Type Vira

Class Virolya

Orders:

1. Protophytovirales (phages)
2. Phytovirales (plant viruses)
3. Zoovirales (animal viruses)

On being formed in the course of evolution, these groups apparently did not remain stable: some bacteriophages became adapted to higher plants, while some viruses of lower plants became adapted to bacteria and fungi. Similar interrelationships could arise between animal viruses and plant viruses, etc. A more detailed investigation of viruses will show how much truth there is in such assumptions. For that reason the subdivision which has been proposed is not based on the species of hosts in the organism of which the viruses in question lead a parasitic existence at the present time, but indicates the pedigree of the virus and its origin.

In defining the concept of species we started from the basic percept of Michurin Biology, according to which species are not an abstract concept but actually existing links of the total biological chain of development (Lysenko). For that reason we define a species of viruses as a conglomeration of individuals which has formed during the course of evolution and is characterized by a common morphology and common biological characteristics. In defining the concept of species, we take into consideration the modifiability of viruses and their adaptation to definite conditions of existence, which comprises the capacity to induce definite infectious diseases.

On the basis of the considerations made above, we list below a systematic classification and nomenclature of viruses which affect human beings and animals. The diseases produced by the virus species in question are indicated in parentheses. Naturally, our table does not systematize all of the viruses known at the present time. For instance, the viruses which are the causative factors of virus diarrhea, the Capozzi syndrome, Durand's disease, infectious mononucleosis, epidemic keratoconjunctivitis, epidemic myalgia, etc., have not been included. Furthermore, some causative factors of animal diseases, as for instance equine typhoid and the plague of horses, periodic ophthalmia, the pest of guinea pigs, etc., have also not been included. As the investigation of viruses progresses, those which have not been classified will be assigned to their proper place and given names within the system of classification.

There can be no doubt that the system of classification which has been proposed requires some improvement. For instance, viruses which have dimensions diverging too widely and for that reason are very different with respect to their biological properties have been included in the genus Tumefaciens, together with large viruses which are visible under an ordinary microscope. The causative factor of chicken sarcoma, which is a small virus, has been included in this genus. Further differentiation of families and genera is necessary in the suborders Mesovirineae and Microvirineae. As further investigation of viruses is carried on, these shortcomings can be eliminated.

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Nevertheless, we are of the opinion that the systematics and nomenclature proposed by us will serve in its present form as a basis for the development of an improved and comprehensive systematization of viruses, which will constitute the final result of collective work done by Soviet virologists who are investigating various divisions of this young but rapidly progressing branch of science.

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- Order Zoovirales C-O-N-F-I-D-E-N-T-I-A-L
- Suborder I. Rickettsiinea
- Family I. Rickettsiaceae
- Genus 1. Rickettsia
- Subgenus Rickettsia
1. R. prowazeki (typhus)
 2. R. mooseri (rat rickettsiosis)
- Subgenus Dermacentrexenus
1. D. rickettsi (Rocky Mountain spotted fever)
 2. D. conori (Marseilles fever)
 3. D. sibiricus (Siberian tick-transmitted typhus)
 4. D. australis (Australian tick rickettsiosis)
- Subgenus Acaroxenus
1. A. varioloidis (rickettsial pox)
- Genus 2. Trombidixenus
1. T. orientalis (tsutsugamushi disease)
- Genus 3. Coxiella
1. C. diaphana (Q-fever)
- Genus 4. Welhynia
1. W. quintanae (trench fever)
 2. W. rutchkovskyi (paroxysmal rickettsiosis)
- Genus 5. Kurlcva
- Subgenus Coxiella
1. C. ruminantium (hydropericarditis of cattle)
- Subgenus Ehrlichia
1. E. kurlovi (ehrlichiosis of guinea pigs)
 2. E. canis (ehrlichiosis of dogs)
 3. E. bovis (ehrlichiosis of cattle)
 4. E. ovis (ehrlichiosis of sheep)
 5. E. microti (parasite of vole leukocytes)
- Family II. Chlamydozoaceae
- Genus 1. Rickettsiaformis
1. R. psittacosis (psittacosis)
 2. R. ornithosis (ornithosis)

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3. *R. pneumoniae* (atypical human pneumonia)
 4. *R. meningopneumoniae* (meningopneumonia of mice)
 5. *R. felis* (feline pneumonia)
 6. *R. muris* (pneumonia of mice)
 7. *R. lymphogranulomatis* (venereal lymphogranuloma)
- Genus 2. *Chlamydozoon*
1. *Chl. trachomatis* (trachoma)
 2. *Chl. oculogenitale* (conjunctivitis of humans)
 3. *Chl. pecoris* (ophthalmia of farm animals)
 4. *Chl. pullorum* (ophthalmia of chickens)
- Suborder II. *Macrovirineae*
- Family I. *Strongyloplasmaceae*
- Genus 1. *Strongyloplasma*
- Subgenus *Strongyplasma*
1. *S. variolae* (smallpox)
 2. *S. vaccinia* (cowpox, vaccinia)
- Subgenus *Horreliota*
1. *H. ovium* (smallpox of birds)
- Subgenus *Zoovariola*
1. *Z. porci* (smallpox of hogs)
 2. *Z. ovium* (smallpox of sheep)
- Subgenus *Varicella*
1. *V. varicellae* (chickenpox)
 2. *V. zonae* (shingles)
- Genus 2. *Latens*
- Subgenus *Latens*
1. *L. herpes* (herpes)
 2. *L. pseudorabiei* (Rabies disease)
 3. *L. ectromeliae* (infectious ectromelia)
 4. *L. paravaccinae* (paravaccinia)
 5. *L. cuniculi* (virus III)
 6. *L. simii* (virus B)

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Subgenus *Ulcerogenes*

1. *U. ovium* (ovine balanoposthitis and stomatitis)
2. *U. vitulorum* (erosive stomatitis of cows)
3. *U. equorum* (vesicular equine stomatitis)
4. *U. pullorum* (laryngotracheitis of chickens)

Family II. *Neurorhynchaceae*Genus 1. *Neurorhynchus*

1. *N. rabiet* (rabies)

Genus 2. *Dermatolysator*

1. *D. hominis* (diffuse encephalomyelitis)
2. *D. vulpis* (encephalomyelitis of silver foxes)

Genus 3. *Vyscholeskyella*

1. *V. equina* (old-world equine meningoencephalitis)

Family III. *Tumefaciaceae*Genus 1. *Tumefaciens*

1. *T. verrucarum* (warts)
2. *T. mollusci* (molluscan contagiousum)
3. *T. bovis* (papilloma of cows)
4. *T. canis* (papilloma of dogs)
5. *T. fibromyxomatis* (fibromyxoma of rabbits)
6. *T. gingivalis* (oral papilloma of rabbits)
7. *T. papillomatis* (Shope's papilloma)
8. *T. lactogenes* (cancer of the lactic glands of mice)
9. *T. muris* (Zil'ber's inoculable cancer of mice)
10. *T. sarcomatis* (Rous sarcoma)
11. *T. ranae* (cancer of leopard frogs)
12. *T. cyprinus* (epithelioma of fish of the family Cyprinidae)

Suborder III. *Mesovirineae*Family 1. *Pneumophilaceae*Genus 1. *Pneumophilus*

1. *P. gripposus* (influenza)
2. *P. rhinidis* (virus cold)
3. *P. pneumoniae* (atypical pneumonia)

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4. *P. vitulorum* (pneumoenteritis of cattle)
- Genus 2. *Glandulophilus*
1. *G. parotitidis*
- Genus 3. *Pestigenes*
1. *P. canis* (canine plague)
2. *P. felis* (feline gastroenteritis)
3. *P. suis* (hog cholera)
4. *P. bovis* (rinderpest)
5. *P. pullorum* (fowl plague)
6. *P. aegypticum* (Egyptian pseudoplague of chickens)
7. *P. newcastlei* (Newcastle disease)
- Genus 4. *Maculigenes*
1. *M. morbillorum* (measles)
2. *M. rubellae* (German measles)
- Family II. *Haemorrhagogenaceae*
- Genus 1. *Haemorrhagenes*
1. *H. crimae* (Crimean hemorrhagic fever)
2. *H. sibiricus* (Omsk hemorrhagic fever)
3. *H. orientalis* (Manchurian hemorrhagic fever)
4. *H. nephritidis* (hemorrhagic nephroso-nephritis)
- Family III. *Hepatophilaceae*
- Genus 1. *Hepatophilus*
1. *H. hominis* (infectious hepatitis)
2. *H. muris* (hepatopathy of mice)
3. *H. suillus* (hog hepatitis)
- Suborder IV. *Microvirineae*
- Family 1. *Neurophilaceae*
- Genus 1. *Encephalophilus*
1. *E. silvestris* (spring-summer encephalitis)
2. *E. scotticus* (Scotch encephalitis)

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3. *E. japonicus* (Japanese encephalitis)
 4. *E. americanus* (St. Louis encephalitis)
 5. *E. australis* (Australian encephalitis)
 6. *E. nili* (Western Nile encephalitis)
 7. *E. equinus* (new-world equine encephalomyelitis)
- Genus 2. *Neurophilus*
1. *N. poliomyelitis* (poliomyelitis)
 2. *N. choriomeningitis* (choriomeningitis)
 3. *N. muris* (Theiler's murine encephalomyelitis)
 4. *N. mongo* (Kengo's encephalomyelitis)
 5. *N. caviae* (paralysis of guinea pigs)
 6. *N. gallinarum* (encephalomyelitis of chickens)

Family

II. Viscerophilaceae

- Genus 1. *Viscerophilus*
1. *V. tropicus* (yellow fever)
 2. *V. dengue* (dengue fever)
 3. *V. pappataei* (pappataei fever)
 4. *V. africanus* (Rift Valley fever)
 5. *V. senliki* (Senliki Forest virus infection)
 6. *V. bwamba* (Bwamba fever)
 7. *V. colorado* (Colorado tick fever)

Genus

2. *Sanguiphilus*
1. *S. equinus* (equine infectious anemia)
 2. *S. ovis* (pernicious anemia of sheep and goats)
 3. *S. felis* (agranulocytosis of cats)
 4. *S. canis* (infectious anemia of young dogs)
 5. *S. gallinarum* (infectious leukemia of chickens)

Family

III. Microviraceae

- Genus 1. *Microvirus*
1. *M. pecoris* (foot-and-mouth disease)

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